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Issued May 25, 1914.

HAWAII AGRICULTURAL EXPERIMENT STATION,

E. V. WILCOX, Special Agent in Charge.

Bulletin No. 34.

TOBACCO INSECTS IN HAWAII.

BY

D. T. FULLAWAY,

ENTOMOLOGIST.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

HONOLULU, HAWAII, *August 16, 1913.*

SIR: I have the honor to submit herewith and recommend for publication as Bulletin No. 34 of the Hawaii Experiment Station a paper on Tobacco Insects in Hawaii, by D. T. Fullaway, entomologist. The extension of the tobacco industry in Hawaii in the past few years has made desirable a further study of the insect pests of tobacco, and the results of these studies, together with practical recommendations for the control of tobacco insects, are presented in this bulletin.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON, *Secretary of Agriculture.*

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TOBACCO INSECTS IN HAWAII.[1]

INTRODUCTION.

A general account of the insects known to feed on tobacco was presented as a bulletin of this station by D. L. Van Dine.[2] This bulletin, however, was prepared while the experimental work on tobacco was still in progress and before any large areas had been planted. In the meantime the industry has become established and the plantings greatly extended, and in view of the facilities for obtaining and importance of having actual and complete information in regard to the pests encountered in the tobacco fields, the entomological work reported herein was begun several years ago and continued to date. The present paper, then, is intended to supplement the information contained in the previous bulletin, and in addition to listing the insects gives an account of the distribution, life history, habits, means of control, and natural enemies of each of the species enumerated, together with other data gathered through study and observation during the course of the work.

The principal tobacco pests are cutworms, splitworm, pod-borer, hornworm, flea-beetle, and cigarette beetle. Many minor pests are also encountered without being especially destructive. These may be discussed in two categories, namely, those affecting the plant and those affecting the product.

INSECTS AFFECTING THE PLANT.

CUTWORMS.

Cutworm is a general term used to designate the large ground-inhabiting caterpillars of the noctuid moths which usually leave their diurnal retreats at night to feed on any vegetation at hand. "Peelua" is the native word by which these worms are known. The Noctuidæ are represented in these islands by 35 or more native and introduced species. Of these, however, only eight are commonly found in cultivated fields; the others are more or less confined to the mountains and the native flora and are not generally encountered as agricultural

[1] The habits and life histories of the cutworms, splitworm, tobacco pod-borer, hornworm, tobacco flea-beetle, and cigarette beetle, and a number of pests of minor importance in Hawaii are described, and practical recommendations are made regarding the control of each of them.

[2] Hawaii Sta. Bul. 10.

pests. While the cutworms as a group are generally held in check by very efficient parasites, on account of their great reproductive powers and the wide range of their food plants they are seasonally very destructive, especially in newly broken or poorly cultivated fields, when a dearth of food compels them to migrate in numbers. The winter months, when the parasites are numerically at a low ebb and the reviving vegetation gives the cutworms an impetus to increase, are usually the season of cutworm activity and widespread destruction of crops.

Caradrina reclusa is the species most commonly found in the tobacco fields in Hawaii (fig. 1). This is a recently introduced species, not listed in the Fauna Hawaiiensis. According to Swezey, it was first noticed in numbers in 1906, although Perkins had taken

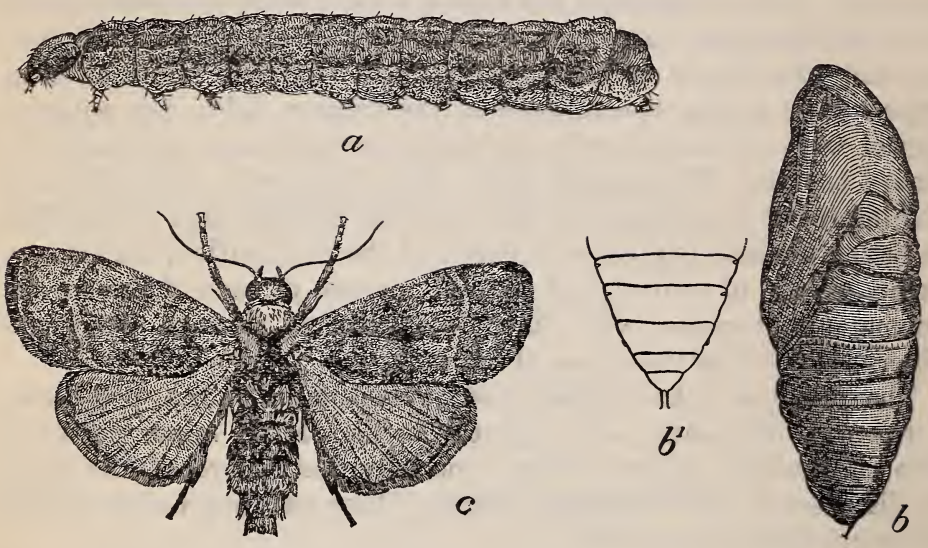

FIG. 1.—*Caradrina reclusa*, a cutworm common in tobacco fields: *a*, Larva; *b*, pupa; *c*, moth. (Original.)

specimens a few years previous to 1906. Its habitat is given as Nilgiris, Ceylon, Borneo, and Fiji, and it has probably come to Hawaii from the last-named locality.

A full account of its life history is given by Swezey,[1] from which the following data are taken:

The eggs are not laid in a mass or cluster, but are scattered around singly or in small numbers; on the surface of grass leaves they are sometimes laid in rows; they are also at times placed on any hard surface. One moth in captivity laid 216 eggs. It died after four days.

The egg is hemispherical, with the flattened surface next the leaf; it is ribbed meridianally with about 30 ribs, 10 of which reach the upper pole; there are also slight cross ridges between the ribs; at the

[1] Proc. Haw. Ent. Soc., 2 (1908), No. 1, p. 3.

upper pole is an irregular patch of reddish color; there is also an irregular ring of the same color at about one-third the distance from pole to base of egg; the rest of the egg is pale green; when first laid it is entirely pale green.

The full-grown larva is 26–32 mm. long and almost black. The two preceding stages are more mottled and variegated with black, brown, olivaceous, yellowish and whitish, darker colors, however, predominating. There are two more or less conspicuous subdorsal rows of black spots on segments 7–12 and a broad paler region on dorsum between these, in the middle of which is a series of obscure lozenge-shaped darker spots. The head is mostly black except the periphery (i. e., the portion covered when retracted), which is pale brown. There are two conspicuous whitish subdorsal spots on segment 6, and the posterior subdorsal parts of segment 12 and upper parts of segment 13 are yellowish. The spiracles are black with a yellowish streak below them. The tubercles are not conspicuous but about the same color as their surroundings, and the hairs are short. The twelfth segment is quite swollen. The duration of the larval stage is 30–40 days.

FIG. 2.—*Frontina archippivora*, parasitic on cut. worms. (From Swezey.)

The pupa is formed in the soil, an inch or two below the surface. It is 13–15 mm. long, uniform medium brown; eyes black; wing, leg, and antennal cases extending to apex of fourth abdominal segment; the articulations between segments 4–7 movable. There is a row of about 20 pits on dorsal part of basal margin of segments 5, 6, and 7, from the ends of which a band of punctures extends around the ventral side. The apex of the abdomen is blunt and rounded, with two approximate dark spines, the tips of which converge and are slightly curved ventrally. The pupal period is 12–14 days.

The moth is described as follows:[1]

♀ Pale chestnut brown. Fore wing with very faint traces of the usual markings; a prominent ochreous postmedial line slightly curved from the costa to vein 2, and not waved. Hind wing paler.

♂ With the collar and abdomen black; the second joint of palpi black. Fore wing with the basal area clothed with ocherous hair; hind wing with the base yellowish; some specimens have a black speck in cell of fore wing and series of specks on the postmedial line and margin.

On the few productive plantations here this cutworm is by long odds the most destructive pest encountered. Six and seven replant-

[1] Hampson. Fauna Brit. India; Moths, 2 (1894), p. 264.

ings are often required to secure a stand, in spite of the most thorough distribution of poisoned bait and handpicking. Inability to control the cutworms in these plantations is due largely to the character of the land, which is rocky and unworkable. With thorough cultivation, cutworms become almost a negligible quantity after the lapse of several years, except for occasional outbreaks which are, for most species, of rare occurrence.

Next to thorough cultivation the best artificial control of cutworms is secured by distributing about the plants a poisoned bait—white arsenic or Paris green in moistened and sweetened bran, flour, or middlings. The edges of fields adjacent to uncultivated land are often trenched, so as to present a steep surface on the exposed side which the cutworm can not climb. Hand picking is sometimes resorted to, but is altogether too slow and expensive.

As already stated, the present parasites of cutworms are fairly efficient throughout the year; these are the tachinid flies, *Frontina archippivora* (fig. 2) and *Chætogædia monticola*, the ichneumon fly, *Ichneumon koebelei* (fig. 3), and the egg parasite, *Trichogramma pretiosa*.[1] Birds also devour large numbers.

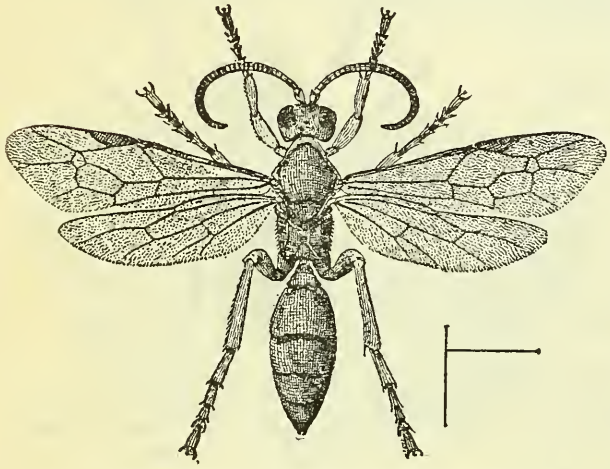

FIG. 3.—*Ichneumon koebelei*, parasitic on cutworms. (From Swezey.)

The loss from cutworm injury, especially in diversified farming, is a serious matter and should have more attention than it at present receives. For instance, with Government assistance it might be possible to get by importation many additional cutworm parasites. Insectivorous birds also should be protected by law or by the cooperation of owners of land used for agricultural purposes, and more insectivorous species might be secured by importation.

SPLITWORM.

The splitworm of tobacco is the caterpillar of the common gelechiid moth, *Phthorimæa operculella* (fig. 4), a widely distributed pest of Irish potatoes, tomatoes, eggplants, and other solanaceous plants, as well as of tobacco. The moth was described in 1878 from specimens from Texas and its destructiveness to solanaceous plants came to notice shortly afterwards. Within a decade it was reported as an agricultural pest from various parts of the United States and the

[1] This parasite, or *T. flavum*, which is probably only a synonym of *T. pretiosa*, has been bred from the eggs of a noctuid, probably *Spodoptera exigua*.

West Indies, from Algeria and the Canary Islands in Africa, and from Australia and New Zealand in Polynesia. It was first noticed in Hawaii in 1892 by Perkins and Blackburn, when it had undoubtedly been here some time.

The caterpillar, as indicated in the designation "splitworm," mines the leaves of its host plants, making a broad, flat track through the mesophyll between the upper and lower epidermis, which often becomes badly split and shattered when dry. It sometimes also tunnels the stem, which thereby becomes greatly weakened.

As a tobacco pest this species is most injurious to seed bed plants. When the seed bed is invaded the plants are generally set back and sturdy seedlings for transplanting difficult to obtain. This trouble may be partly overcome by seeding the beds very thin and protecting them from the moth with cotton netting. The damage to plants in the field is slight on well-conducted plantations, and it is usually only the two or three poor, soiled, lower leaves that are much split by the worm. Where, however, a planting is neglected the infestation becomes general and any tobacco in proximity to the neglected fields will be badly split.

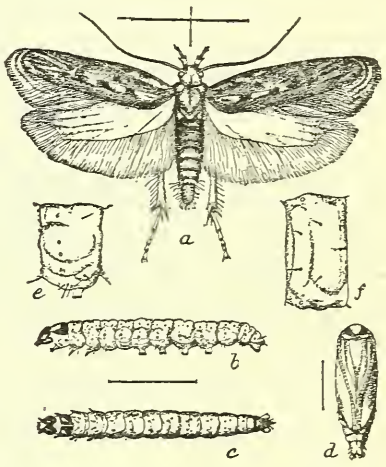

FIG. 4.—*Phthorimæa operculella*, the tobacco splitworm: *a*, Moth; *b*, larva, lateral view; *c*, larva, dorsal view; *d*, pupa; *e*, *f*, segments of larva, enlarged. (Redrawn from Riley & Howard.)

Life history.—There are four distinct stages in the life cycle of this insect, namely, the egg, larva or caterpillar, pupa, and adult.

The egg: The eggs are laid singly on the leaves, often in the hollow alongside the veins. They are oval to pear shaped, 0.45 mm. long by 0.27 mm. across, pearly white, and faintly reticulate. About 20 to 25 eggs are laid by a single moth. The egg stage occupies six days.

The larva: The full-grown larva is a rather slender worm, about 10 mm. long, in color sordid white with a greenish or reddish tinge; the head, cervical shield, legs, and antennæ brown to black. The cervical shield is broad and wide, almost reaching the posterior margin of the segment; the lateral hind angles rounded. The tubercles are fuscous to black, mostly minute, bearing setæ, and are arranged in longitudinal rows as follows: (1) anterior, (2) posterior and a trifle more removed than 1, (3) above spiracle, (4+5) below, (6) posterior, below fold, (7) ventral; on segments 2 and 3 (1) and (2) are in a line at about middle of segment, while (3), (4), and (5) form an equilateral triangle, (3) and (4) rather large; on first segment the spiracle is posterior, and in front of it there is a large, flat tubercle with three long hairs.

The larval stage occupies about 26 days. Before pupating the worm usually leaves its mine or tunnel and finding a hidden or obscure corner builds a cocoon of silk and grass or grains of soil within which it pupates.

The pupa: The pupa, removed from its case, is brown, about 6 mm. long, and rather slender. The wing cases distally are free from the abdomen; the leg and antennal cases are scarcely longer than these, and reach the apex of the sixth segment. The cremaster is lobed, and between the lobes dorsally is a short, stout spine surrounded by numerous hairs with recurved tips. The pupal stage covers 11 days.

The moth: The moth is described by Walsingham [1] as follows:

Antennæ brownish cinereous. Palpi cinereous, with two umber-brown patches on the median joint externally, a spot of the same on the base of the terminal joint and a broad band before its apex. Head brownish cinereous; face pale cinereous. Thorax brownish cinereous, with three smoky brown longitudinal lines above. Fore wings dull buff-brown, shaded and spotted with dark smoky brown; this forms a dorsal shade below the fold, a terminal shade reverting around the apex, and a spot at the end of the cell from which narrow lines radiate outward along the veins; there are also two spots near the base of the costa, the first succeeded by another below and beyond it, the second followed by one on the cell and one on the fold in an oblique line, a pair of smaller spots lying beyond this line on the cell, also in oblique succession; cilia pale buff-brownish, sprinkled along their base with smoky brown. Exp. al. 15–16 mm. Hind wings pale gray; cilia pale brownish ochreous. Abdomen and legs brownish cinereous.

Remedies.—As the insect in its injurious stage is generally protected in its tunnel, poisons are of little use in attempting to control it artificially. It is well known, however, that the worm often deserts an old mine to form a new one and the hatching caterpillars must in the first place eat through the epidermis; to this extent, therefore, they are vulnerable to lead arsenate dusted or sprayed on the plants, and this measure is recommended for the control of the worm in seed beds. If the arsenic is applied as a spray it can be combined with the Bordeaux mixture used in case of fungus troubles. Under field conditions, however, the little good accomplished and the great expense involved make it scarcely worth while. As already mentioned, the beds can be protected by screening. As a precaution against a general infestation, no solanaceous plants should be grown near the tobacco fields and all solanaceous weeds in the immediate vicinity should be periodically destroyed.

Natural enemies.—The caterpillars of the splitworm are very much parasitized by a small black and white braconid, *Chelonus blackburni*, which likewise attacks a number of other small leaf-rolling caterpillars. The parasitized caterpillars spin their cocoons when about half grown without pupating. Shortly afterwards the larva of the

[1] Fauna Hawaiiensis, vol. 1, pt. 5, p. 484, 1907.

parasite emerges from the caterpillar and feeding on it externally finishes it off and spins its own delicate white cocoon inside that of its host. The parasite emerges a little later than the moth would have done.[1]

It is also much parasitized by a native ophionid, *Limnerium blackburni*, common to many of the smaller pyralids, and with very similar habits to the parasite referred to above.

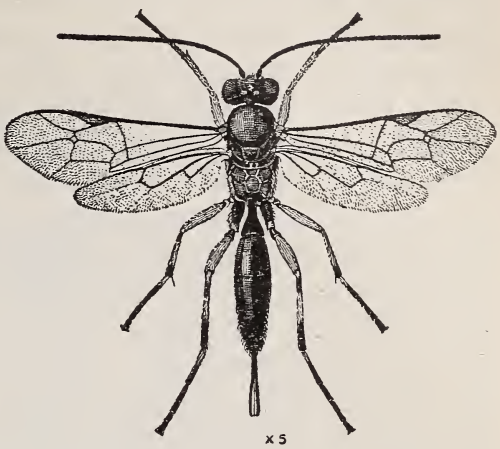

FIG. 5.—*Limnerium blackburni*, parasitic on splitworm. (From Swezey.)

POD-BORER.

The tobacco pod-borer, more familiar in some quarters as the cotton bollworm and the corn earworm, is the larva, or caterpillar, of the noctuid moth *Heliothis obsoleta*, a cosmopolitan pest of omnivorous habit, often very destructive to such important field crops as cotton, corn, tobacco, tomatoes, etc. (fig. 6). On the tobacco plant its characteristic injury is the boring and eating of the seed pods, although it also eats the foliage to some extent. Curiously enough, in Hawaii it is never found on either corn or cotton and is not generally considered a serious pest to tobacco. Its multiplication is probably in some way checked or controlled, most likely by natural enemies, although these have never been disclosed.

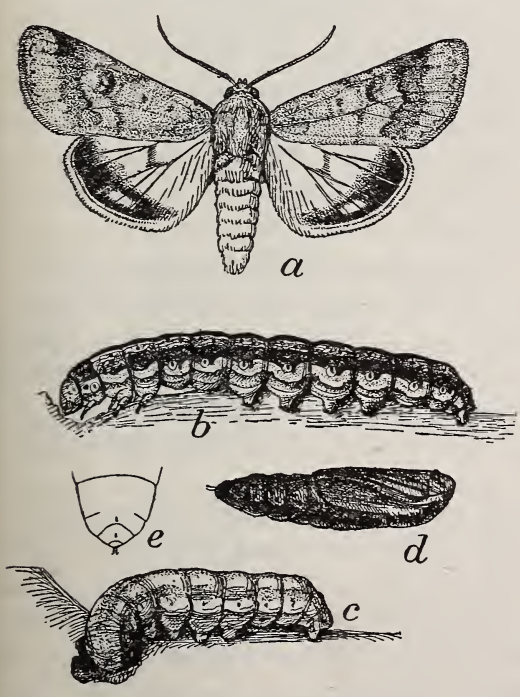

FIG. 6.—*Heliothis obsoleta*, the tobacco pod-borer. *a*, Adult moth; *b*, dark full-grown larva; *c*, light colored full-grown larva; *d*, pupa—natural size. (From Howard.)

Life history.—There are the usual four stages in its development.

The egg: The eggs are laid singly, in a considerable number, and are generally well scattered. They are rather large and conspicuous; sometimes they are found near the bud in young plants, most usually however on the flower, the pod, or the subtending bracts, rather loosely attached

[1] Hawaiian Sugar Planters' Sta., Div. Ent. Bul. 5, p. 41 (1907).

but adhering readily to the sticky surface of the plant. The egg is pearly white, spherical (diameter about 0.6 mm.), radiately ridged on the sides from a smooth circular area on the dorsal summit surrounding the micropyle, the longitudinal ridges connected by short cross ridges. The egg stage is five days.

The larva: The larva is extremely variable and for that reason difficult to describe. Freshly hatched specimens are about 0.75 mm. long, sordid white with black head and fuscous cervical shield, and covered with black hairs. Four or five molts occur in the course of its growth, the color often changing in the molt. The full grown caterpillar is 30–40 mm. long, stout bodied, the integument more or less shagreened through the presence of extremely closely set, short, stout spines; the principal varieties greenish, reddish, and grayish, and longitudinally striped—usually a broad dorsal and two broad lateral dark stripes above the pale stigmatal line, with many fine wavy lines intermixed. The head and cervical shield are brown, the latter with irregular black markings. Spiracles black with white center. Tubercles variable, some large and black, others small and pale, and arranged in longitudinal rows as follows: On segments 4–9 (1) is anterior, (2) posterior and farther removed from median line, (3) above spiracle, (4) behind and (5) under and beneath the stigmatal line; in some cases (4) is small and (5) is in all cases. On the segments with prolegs (6) is above the leg; on the segments without them (6) and (7) are ventral and posterior. On segments 2 and 3 (1) and (2) are in line and (1) is small; (3) is close to (2) and also in line; (4) and (5) are small, the latter behind the former on the stigmatal line, (6) above the leg. On segment 1 (1) is anterior, (2) posterior and farther removed, (3) is above spiracle, (4+5) in front, (6) above the leg. On segment 10 (4) is behind (5), which is below the spiracle; on segment 11 (4) is absent. The length of the larval stage is 32 days. When full grown the larva leaves the plant to enter the soil, fashioning a rough cell several inches below the surface in which it pupates.

The pupa: The pupa is of the usual stout noctuid type; length about 20 mm.; smooth and brown. The wing cases end broadly, the leg and antennal cases narrowly, at the apex of segment 4. The spiracles on segments 2–7 are contracted oval, raised above the integument into a short neck, and are black; that on segment 8 is a mere narrow slit. The anterior margin of segments 4–7 dorsally and 5–7 ventrally are punctate, the punctation rather fine on segment 4, otherwise coarse. The cremaster is rather pointed, with two fairly long projecting spines. The length of the pupal stage is 12–16 days.

The moth: The adult moth is described as follows:[1]

[1] Hampson. Fauna Brit. India; Moths, 2 (1894), p. 174.

Ochreous with a pale brown, olive, or red-brown tinge. Fore wing with indistinct double waved antemedial lines; a dark speck representing the orbicular; an indistinct curved medial line; the reniform indistinct; postmedial and submarginal waved lines, the space between them somewhat darker and with a series of pale or dark specks on the nervules; a marginal series of dark specks. Hind wing white; the veins fuscous; a broad blackish outer border usually with a pale submarginal central patch. Underside of fore wing with the orbicular and reniform stigmata conspicuously black; a broad blackish band beyond the postmedial line; the apices of both wings and outer area of fore wing pinkish.

Remedies.—As already stated, the pod-borer is not a serious pest of tobacco. It is the general practice of planters to top the plants as soon as the flowers appear, and where this is done consistently there is little evidence of the pod-borer. To obtain seed, the flower stalks are usually inclosed in a bag. Neglected fields, however, always show signs of the borer if the eggs or worms are not actually present in numbers. Under the circumstances it is unnecessary to recommend any remedial measures beyond the avoidance of neglecting a regular routine in field work. If for any reason a field of standing tobacco is abandoned, the plants should be plowed up and destroyed to avoid a general infestation.

Natural enemies.—The eggs of the pod-borer moth are probably parasitized, here as elsewhere, by *Trichogramma pretiosa*, although the parasite has never to my knowledge actually been bred here from Heliothis eggs. It is also possible that the common tachinid parasites attack Heliothis, but there is no positive evidence at hand.[1]

HORNWORM.

Hornworms are the familiar, large, repulsive-looking caterpillars of the hawk moths, with large head and prominent horn or spine at the hind end of the body. The moths are also large and heavy-bodied and resemble humming birds as they hover around open blossoms in the late afternoon. There are several native species which are only rarely seen in the mountains, but the strong flying moths often get down to the coast. The commoner introduced species are found, *Sphinx convolvuli* on sweet potatoes and *Deilephila lineata* on purslane. The tobacco hornworm, *Phlegethontius quinquemaculata* (fig. 7), is extremely uncommon and has never been seen by the writer on tobacco. It is sometimes found around Honolulu on the wild tobacco (*Nicotiana glauca*), and on these occasions the broods are usually large, and the plants soon stripped. Its rare occurrence would indicate the presence of very efficient parasites.

The tobacco hornworm is a North American insect and is known throughout the tobacco districts of the United States as the northern tobacco worm in contradistinction to the southern tobacco worm, *P. sexta*. It must have been introduced here at an early date; it

[1] Since the above was written, *Frontina archippivora* has been bred from the pupa.

was first recorded, however, by Blackburn in 1881 and described by Butler on Blackburn's specimens as a new species, *P. blackburni*. *P. blackburni* later proved to be a synonym, as already indicated.

The larva: The larva is described by Blackburn as follows:[1]

Green or ashy gray, more or less sprinkled with white; spiracular line white, emitting upwards and backwards (i. e., so that they slant upwards in a backward direction) seven white stripes, the first of which is on the fourth segment (not counting the head as a segment), the last on the tenth; on the eleventh segment is a small white stripe bent backwards over the spiracle, being much smaller than the white lines on the other segments; head with two well-defined black longitudinal lines, and clouded with black laterally; spiracles black, surrounded with a bright blue ring;

FIG. 7.—*Phlegethontius quinquemaculata*, the tobacco hornworm. *a*, Adult moth; *b*, full-grown worm or larva; *c*, pupa—natural size. (From Howard.)

horn long, shining black, bent backwards; claspers of the ground color. In the ashy gray larvæ the whole dorsal surface is sprinkled with white; the segment behind the head is shining black, bordered with white; the last claspers and space around the anus are shining black (at least partially); and the legs are blackish at base, becoming red toward apex. In the green larvæ only a few segments near the head are sprinkled with white, and the segment next behind the head, the last claspers, and the space round the anus are olivaceous rather than black; the legs, too, are more conspicuously red.

The pupa: The pupa is of the usual large heavy-bodied sphingid type with projecting tongue case forming the so-called "jug handle."

[1] Ann. and Mag. Nat. Hist., 5. ser., 7 (1881), p. 319.

It is described as rather slender and more or less smooth, the puncturing at base of abdominal segments and at apex fine and shallow. The wing cases are angulate, the tongue case rather long and thin, the tip touching the body at one-third the length from the head. The larvæ pupate 3 or 4 inches deep in the soil within a roughly constructed cell.

The moth: The moth is described as follows:[1]

General color ash gray; fore wings ash gray at base, without white spots. No white dot at middle of wing, this mark represented by a gray dot encircled with black, which does not contrast with the color of adjacent parts. Fringe of outer margin without white. An evident whitish line begins in an enlargement at the angle, and extends forward, parallel with the edge, toward the apex of the wing, but terminates abruptly before reaching it. Outer angle of fore wing decided. Basal two-thirds of hind wing largely light ash gray, the middle of the wing crossed by two sharply dentate black lines, which represent the more or less fused pair on the wing of *P. carolina*. Outer third of hind wing largely ash gray, this area limited within by a wide curved band of black. Head and thorax above ash gray. Abdomen on middle above ash gray, with an evident narrow median black line. Orange spots on side five in number, less elongated transversely and more rounded than in the related species. Legs gray, cross-banded with whitish above.

The following description of the Hawaiian form is copied from Butler:[2]

P. quinquemaculato simillima; major, alis latioribus, magis grisescentibus; signis alarum anticarum subcostalibus albescentibus; serie macularum albarum antice confluentium arcuata discali, cum fascia ordinaria nigrocincta cohærente; fasciola posticarum prima obsoleta; fascia sub-marginali nigra apud apicem multo latiore; alar. exp. unc. 5.

There are no breeding records at hand.

In the United States the life cycle runs through about 45 days; in Hawaii the time would presumably be somewhat shorter.

Remedies.—As already stated, tobacco growers have not found the hornworm a serious pest on account of its rarity. When it does appear it may flourish for a time and do considerable damage; in such a case it is best to check it at once by spraying infested plants with lead arsenate (3 pounds to 100 gallons of water), to which the young worms are very susceptible. If the worms have reached large size before the infestation has been noticed, hand-picking should be resorted to, as it is difficult to kill the large worms with a stomach poison.

Natural enemies.—The natural enemies are not known, but it is probably an egg parasite and not unlikely a trichogrammid. The eggs of the congener *S. convolvuli* are parasitized by the trichogrammid *Pentarthron semifuscatum*.

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[1] Garman. Kentucky Sta. Bul. 66, p. 25.

[2] Ent. Mo. Mag., 17 (1880), p. 6.

FLEA-BEETLE.

The tobacco flea-beetle, *Epitrix parvula* (fig. 8), is one of the phytophagid beetles, a family including many extremely injurious forms, such as the 10-lined potato beetle, the asparagus beetle, cucumber beetle, and a host of other flea-beetles with very similar habits but widely different food plants.

According to Sharp,[1] who vouchsafes for its specific identity, it is a late introduction, not being taken by Blackburn in his collecting here in the late seventies and early eighties. It is of American origin and is generally distributed in the Southern States of the Union, in Mexico, Central America, and the West Indies. Like some other tobacco pests, it feeds on practically all the commoner solanaceous plants, and is equally injurious to potatoes, tomatoes, eggplant, and poha. Both the larva and the adult beetle do damage, but the characteristic injury is the work of the adults on the leaves. The beetles are small and their mouth parts can grasp only small fragments, but they are assiduous feeders, so that the result of their feeding is often a shattered foliage, ragged with spots and holes and broken margins. The larvæ work beneath the surface on the roots and crown, an injury apparently of little consequence, but noticeable in neglected plants. No enemies have been disclosed, but, apparently, some factor interferes to prevent its undue multiplication, else this pest would do widespread injury. In some places there appears to be a seasonal occurrence, the beetle becoming numerous and injurious only in the dry season; but in neglected plantations, and especially in the neighborhood of other solanaceous plants, it is commonly prevalent. The adult beetle is rather long lived, but it should not on this account necessarily be more injurious, as it is able to do without food for long periods.

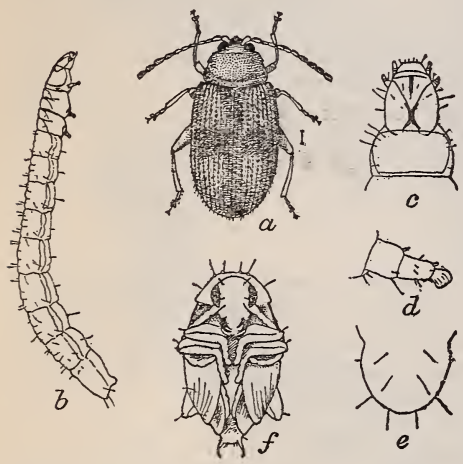

FIG. 8.—*Epitrix parvula*, the tobacco flea-beetle. *a*, Adult beetle enlarged about fifteen times; *b*, young larva; *f*, pupa; *c*, *d*, *e*, portions of the larva greatly enlarged. (From Chittenden.)

The difficult life history has been fully studied in America by Chittenden, and the writer has not attempted to duplicate this work.

Egg: The egg, according to Chittenden,[2] is narrow, elliptical-ovate, two and one-half times as long as wide, color gray with scarcely a

[1] Fauna Hawaiiensis, vol. 2, pt. 3, p. 95, 1900.
[2] U. S. Dept. Agr., Div. Ent. Bul. 19, n. ser., p. 86 (1899).

tinge of yellow, the surface divided into very minute irregular areas only visible under a high magnification. Length 0.4 mm., width 0.18 mm.

Larva: The larva, according to the same authority,[1] is 3.5 mm. long, delicate and filiform or threadlike, milky white in color except the head, which is honey yellow, and with darker brown mouth parts and sutures. The body is subcylindrical, moderately wrinkled and segmented, and sparsely covered with short hairs. The head is only moderately chitinized, and the first, thoracic, and last, or anal, segment are apparently not at all or only slightly chitinized. The anal segment is furnished with a small proleg, but there are no visible denticles at its apex.

Pupa: The pupa is white like the larva and resembles the pupa of Diabrotica, especially in the anal hooklike appendages. The insect pupates in a cell.

Adult: The adult is very minute, measuring scarcely 1.5 mm. in length, is oblong ovate in form, and light brown in color. The elytra are usually marked with a dark transverse median band of greater or less extent.

A life cycle is said to run through 28 days, as follows: Egg, 6 days; larva, 16 days; pupa, 6 days. In Hawaii it would presumably be somewhat shorter.

Remedies.—On the commercial plantations of Hawaii the flea-beetle does not seem to be much of a pest except late in the growing season, but in neglected tobacco it becomes very numerous. For this reason it is necessary in growing tobacco commercially to keep well up in the field work and allow no plants to remain around after the tobacco has been picked. Other solanaceous crops should not be grown near the tobacco, and all solanaceous weeds in the neighborhood should be periodically destroyed. When, however, the flea-beetle is present in sufficient numbers to damage the crop, the affected plants may be sprayed with arsenate of lead, 1 pound to 20 gallons of water, paste form (only one-half of this amount of powdered arsenate of lead), which will kill any beetles feeding on the sprayed foliage.

MINOR PESTS.

There are a few minor pests of tobacco, such, for instance, as the caterpillars of *Plusia chalcites* and of *Amorbia emigratella*, which are rather general feeders and are found on various cultivated and wild plants without being particularly injurious to all of them; and the mealy bugs *Pseudococcus citri* and *Pseudococcus virgatus*, which are also found on many different plants but are noticeably injurious only under exceptional circumstances. In the Kona tobacco fields

[1] U. S. Dept. Agr., Div. Ent. Bul. 10, n. ser., p. 79 (1898).

Siphanta acuta and *Pulvinaria psidii* are also found on tobacco, although they are commoner on the coffee plant, and snails do some damage to seedling and young plants. The grasshoppers, *Elimæa appendiculata* and *Xiphidium varipenne*, are frequently seen on tobacco and may feed on it to some extent, but the injury they do is altogether negligible. A rather common introduced bug (*Nysius delectus*) is also found on the seed pods of tobacco wherever grown, but it has not been ascertained whether or not it breeds on tobacco or is in any way injurious to the plant. There is also associated with tobacco a bark beetle (*Xyleborus* sp.) the larva of which mines the old stems, but it is not especially injurious.

INSECTS AFFECTING THE STORED PRODUCT.

CIGARETTE BEETLE.

The cigarette beetle, *Lasioderma serricorne* (Ptinidæ) (fig. 9), is one of those numerous species which feed altogether on dry, dead vegetable

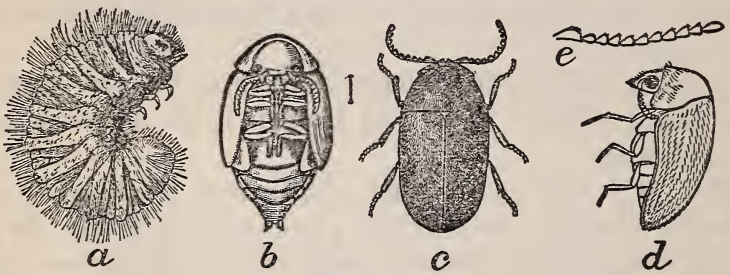

FIG. 9.—*Lasioderma serricorne*, the cigarette beetle. *a*, Larva; *b*, pupa; *c* and *d*, adult; *e*, antenna—greatly enlarged—natural size shown by hair line. (From Chittenden.)

or animal substance, and thus become pests where animal and vegetable products must be stored or kept for future use. Commercial operations and the transference of stored products from one region to another have gradually brought about a world-wide dissemination of many of these species, which in the Tropics are especially injurious and difficult to control. The attachment of the cigarette beetle to tobacco, a commodity in universal use, has given this species peculiar opportunity to attain a wide distribution, and it is now known as a practically cosmopolitan pest. It breeds, however, in various stored products in addition to tobacco—animal as well as vegetable—and often becomes a household pest, attacking the coverings of walls and furniture.

It was first recorded from Hawaii by Blackburn in 1885 [1] and is undoubtedly of early introduction. Previous to commercial tobacco growing it occasionally came to notice as a pest in houses and stores, especially in tobacconists' shops in cigar cases, and was easily con-

[1] Sci. Trans. Roy. Dublin Soc., 2. ser., 3 (1885), p. 243.

trolled by fumigation, the damage done usually being slight. However, with the commercial production of tobacco and the necessity of storing large quantities of tobacco in warehouses over long periods, the cigarette beetle has become a serious pest in the tobacco districts and its control is not at all easy—indeed, it is often practically impossible—and serious damage to the stored leaf, before it can be sold or manufactured, is unavoidable.

There is very little information of a historical, descriptive, or biographic nature in regard to the cigarette beetle. On account of its peculiar habits and common occurrence, however, the beetle is unusually well known even to the business man. It can be recognized from the following brief description: The eggs are said to be white and very minute. The larva is a short, stout, hairy, sordid white grub, between 3 and 4 mm. long, with well-defined chitinized head and three pairs of short legs. The integument of the body is much wrinkled and the body itself is usually somewhat bent. The adult beetle is about 2.5 mm. long, reddish brown, and covered with pale hairs. The antennæ are regularly serrate and fairly long. The male is slightly smaller than the female.

Mackie [1] in the Philippines states that eggs hatch 11 days after deposition and that the pupal stage covers 15 days. The length of the larval stage is not given.

Remedies.—The usual method of destroying the cigarette beetle is to expose it to the action of poisonous gases, either the fumes of carbon bisulphid or of hydrocyanic-acid gas. This method gives admirable success where the infestation is only incidental and local and the infested material can be placed in a tight compartment so that the gases can be confined and their full strength utilized. But when the infestation becomes general, as in warehouses in which stored products are being continually handled, it is exceedingly difficult to control the beetle with gases or by any other means, and the only relief that can be obtained is in a systematic fumigation of the whole warehouse from time to time, or different parts of it which can be rendered tight against the diffusion of the gas. Sometimes, also, it is a distinct advantage to spray the floors and walls with benzine or kerosene. In the tobacco industry, baled tobacco offers the greatest resistance to palliative measures, and no satisfactory method of treatment has yet been devised for it. Manufactured goods are often kept in cold storage to prevent beetle injury, and as the insect is unable to develop in the presence of such low temperatures (32 to 34° F.), the goods are safe while in storage and if not removed too soon the danger of injury after withdrawal is greatly reduced. It has, however, been shown that even low temperatures continued for

[1] Philippine Agr. Rev., 4 (1911), No. 11, p. 607.

long periods are not sufficient to destroy the vitality of the eggs of the cigarette beetle and the freezing method is therefore not absolutely preventive.

In fumigating with carbon bisulphid use it at the rate of 1 pound to 600 to 800 cubic feet of air space, pouring the liquid out into shallow pans near the ceiling (the gas is heavier than air), first making the building or compartment as tight as possible against leakage of the gas. Small lots of infested tobacco can be fumigated in air-tight boxes, using 1 ounce of carbon bisulphid to 50 to 60 cubic feet of air space. Caution is advised in the use of this chemical on account of its poisonous and inflammable nature.

Hydrocyanic-acid gas is perhaps not so effective against stored-product insects as carbon bisulphid, but has advantages in cost and ease of use. It is generated by placing cyanid of potassium in sulphuric acid and water. It is lighter than air, and therefore, contrary to the rule with carbon bisulphid, should be generated beneath. Use in proportions of 1 ounce of 98 per cent pure cyanid, 1 fluid ounce of commercial sulphuric acid, and 2 fluid ounces of water to 100 cubic feet. Care must be exercised in using this treatment on account of the very poisonous nature of the cyanid gas.

Natural enemies.—A Pteromalus was bred from this species.

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